vscode-container-wasm: An Extension of VSCode on Browser for Running Containers Within Your Browser

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Summary

- On-browser VSCode lacks Linux terminal running completely inside browser

- vscode-container-wasm enables to run Linux-based containers and its terminal inside browser

- Options for distributing containers to browsers
  - Pre-converting containers to Wasm images
  - Distributing OCI container images to browsers
Terminals on browser-based VSCode

On-browser VSCode lacks Linux terminal running completely inside browser

- Users can edit code but can’t run it without remote machine
- Linux-based development tools (e.g. compilers) can’t run in browser
Browsers don’t provide Linux-compatible system

- Linux-based apps needs re-implementation to run inside browser
- Wasm lacks Linux-compatibility (e.g. no fork/exec)
- Can we run unmodified Linux terminal & dev environment inside browser?
An experimental VSCode extension for running containers **inside browser**

- Workspace mounted at `/workspace/`
- HTTP(S) networking available w/ restrictions by browser (e.g. CORS)
How to distribute containers to browsers?

- Option A: Pre-converting containers to Wasm images
- Option B: Distributing OCI container images to browsers
Option A: Pre-converting containers to Wasm w/ container2wasm

- An experimental **Container to Wasm** image converter
- **Pros:** container can run on non-browser VM (e.g., wasmtime) as well
- **Cons:** Pre-conversion is needed for each container to run

```bash
$ c2w ubuntu:22.04 ubuntu.wasm
```

**Example of .vscode/settings.json**

```json
{
  "container.imageLocation": "https://ktock.github.io/image-example/amd64-gcc-debian-wasi",
  "container.imageChunks": 9
}
```
Option B: Distributing OCI container image to browsers

- Registry needs to allow CORS access
  - But public registries doesn’t allow CORS as of now
  - Try it on localhost registry with CORS header configured
    - https://github.com/ktock/container2wasm/blob/v0.6.2/extras/imagemounter/README.md#example-on-browser--registry
- Or, upload the container to HTTP(S) server in **OCI Image Layout** (files layout of `docker save` >= v25)

Example of `.vscode/settings.json`

Container registry

```json
{"container.containerImage": "localhost:5000/ubuntu:22.04"}
```

OCI Image Layout over HTTPS

```json
```
Example: Containers on github.dev

FROM debian:sid-slim
RUN apt-get update && apt-get install -y gcc

- Container image: gcc on Debian
- Workspace mounted at /workspace/
- HTTP(S) networking is available

https://github.dev/ktock/vscode-container-wasm-gcc-example?vscode-coi=on
• Demo Page
  ○ https://github.com/ktock/vscode-container-wasm-gcc-example

• vscode-container-wasm Repo
  ○ https://github.com/ktock/vscode-container-wasm
How it works

- Container and Linux run inside Wasm VM
- Utilizes CPU emulator
  - Bochs (for x86_64 containers)
  - TinyEMU (for RISC-V containers)
- Uses microsoft/vscode-wasm for Wasm/Wasi host
How it works: Mounting workspace to containers

- Workspaces are provided as pre-opened (mapped) dirs to Wasm VM
- Emulator shares pre-opened (mapped) dirs to the guest via virtio-9p
How it works: Networking

- NW stack + HTTP(S) proxy runs inside browser
- Forwards HTTP(S) using Fetch API
- Restrictions by Fetch API
  - Accessible sites limited by CORS
  - Forbidden Headers uncontrollable

Encapsulates raw packets with size header

HTTP/HTTPS

SharedArray Buffer

sock_*

extra APIs for HTTP

virtio-net

Emulator

JS wrapper

Web Worker 1

Web Worker 2

Wasm

Application

Linux

Host JS code (w/ vscode-wasm)

socket_*

API

Packet

HTTP(S) proxy + NW stack

HTTP req/resp

Host JS code (w/ vscode-wasm)
How it works: Pulling containers to browser

- Container is fetched and unpacked inside browser
- Rootfs is mounted to the guest via 9p

Enabled only when “Option B” (Distributing OCI container images to browsers) is configured
Possible use cases of containers on Wasm

- Interactive on-browser linux-based demo
- On-browser development and testing
- Sandboxed execution environment of containers
- Application debugger runnable on browser
- Record & Replay debugging
- etc...
Related works

VMs on browser

- **v86**: [https://github.com/copy/v86](https://github.com/copy/v86)
  - x86-compatible on-browser CPU emulator by Fabian Hemmer
  - Supports wide variety of guest OSes (including Windows)
  - No support for x86_64

- **TinyEMU**: [https://bellard.org/tinyemu/](https://bellard.org/tinyemu/)
  - RISC-V and x86 emulator by Fabrice Bellard
  - Can run on browser
  - Container2wasm uses this for RISC-V emulation
  - No support for x86_64
Future works

- Performance analysis & improvement
  - Possible integration with elfconv: https://github.com/yomaytk/elfconv
    - AOT compiler of Linux/aarch64 ELF to Wasm by Masashi Yoshimura, NTT Corporation
    - Check also 16:00, Feb 4 @ LLVM devroom: “elfconv: AOT compiler that translates Linux/AArch64 ELF binary to LLVM bitcode targeting WebAssembly”, by Masashi Yoshimura, NTT Corporation

- Integration of container ecosystem with browsers
  - Accessing OS package repos (e.g. apk, apt, fedora packages, ...) from browser
  - CORS-allowed container registries

- Graphics support
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